FARMERS' KNOWLEDGE OF INTEGRATED PEST MANAGEMENT: A CASE STUDY IN THE ZANJAN PROVINCE IN IRAN

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Abstract— Integrated pest management (IPM) has been recognized to be a sustainable method for pest prevention, monitoring and control. Farmers' knowledge and participation are key elements of achieving this approach. The purpose of this study was to assess farmers' knowledge and skills of IPM for the farm pest control. The study was conducted in the Zanjan Province of Iran using a case study through qualitative and quantitative data collection techniques such as participatory observations, structured and semi-structured interviews, focus groups, and transect walks with the farmers of the Nimavar Village. The farmers hardly used non-chemical pest control methods (e.g. mechanical and biological techniques and natural enemies) and their awareness of using these methods was low. Although the farmers were to some extent aware of the side-effects of the excessive use of chemical fertilizers and pesticides, they still continued utilizing chemical inputs due to the shortage of knowledge of and little access to the alternative or sustainable techniques and facilities. The farmers showed little access to private or public extension or research institutions for this matter. It is suggested to improve agricultural extension service to facilitate participatory agricultural research, especially using the farmer field school approach and to provide the required chemical and non-chemical inputs in order to make information and inputs more available and accessible. This can make the implementation of IPM projects effective.

Keywords: knowledge, IPM, farmer, chemical pest control, biological pest control, Iran

1. INTRODUCTION

It is estimated that 50 percent of crop production in developing countries is lost to insects. In addition to direct damage and consumption of plants, they act as vectors of many viral diseases and microbial infections (Christou and Capell, 2009). Pesticide use has been the most common technique for controlling pests in the world. Pest control in the west highly depends on chemical inputs, which are expensive and damage the environment. These chemicals are non-selective (killing both pests and beneficial insects) and their constitutive exposure can lead to the evolution of resistance in insect populations. In developing countries, these chemicals are too expensive for farmers and often ineffective against sap-sucking pests (Christou and Capell, 2009). Approximately 3 billion kg of pesticides is estimated to be applied each year worldwide which costs nearly $40 billion a year (Pan-UK, 2003, as cited in Pimental, 2005).

Excessive use of agricultural chemicals, including fertilizers and pesticides, has caused serious environmental problems (George, 2009). A societal demand exists for reduced pesticide usage (Pimental and Paoletti, 2009). Various toxic chemicals can be found in some food crops. Herbicides are the most important pollutant of surface water and groundwater resources. Pesticide resistance has also been reported as a serious challenge in the US. This has caused farmers to apply greater, newer, often more toxic and more expensive pesticides (Pimental and Paoletti, 2009). The negative effects on human health, agroecosystems (e.g., killing beneficial insects), and the wider environment (e.g., non-target species, landscapes and communities) are some other examples of unsustainable consequences of insecticide use. Some point out that pesticides cannot easily be discarded (Devine and Furlong, 2007).

In the US, the environmental and societal costs because of using pesticides are estimated to be $10 billion, which comprises pesticide impacts on public health ($1.1 billion a year); livestock and livestock product losses; increased control expenses resulting from pesticide-related destruction of natural enemies and from the development of pesticide resistance ($1.5 billion a year) in pests; crop pollination problems and honeybee losses; crop and crop product losses; bird ($2.2 billion a year), fish, and other wildlife losses; groundwater contamination ($2.0 billion a year); and governmental expenditures to reduce the environmental and social costs (Pimental, 2005).

It is estimated that pests damage 42 percent of agricultural products in Iran (Asgari, 2009). Pesticides use and study has a 50 year experience in Iran (Heidari, 2010). The estimated amount of different agrochemical pesticides (insecticides, nematicides, fungicides, herbicides and rodenticides) used in Iran is 17-25 million litre a year, which is more than the optimum requirement (Molazadeh, 2010). Although pesticides have had economic value by controlling some pests, the excessive, unecological and inappropriate use of them have created side effects such as resistance to pesticides, outbreak of new or secondary pests, toxicity, poisoning, causing cancers and genetics disorders (Abdollahi et al., 1999; Abdollahi et al., 2004; Shadnia et al., 2007; Soltaninejad et al., 2007; Heidari, 2010).

IPM has been introduced as a sustainable approach for preventing, monitoring and controlling pests (Olkowski, 1991; Drlik et al., 2001). It tries to integrate natural, chemical and biological techniques to combat pests (Röling and Pretty, 1997). Therefore, it utilizes a combination of techniques and measures in this regard. While it tries to avoid pest problems at the outset, it monitors the crop in case something significant goes wrong (Speight and Evans, 2004). IPM is an approach to suppress pests by the least toxic measures and it does not exclude the use of chemical pesticides. Pesticides are used sparingly and only as a last option. This approach through a package of tactics minimizes economic and environmental costs and improves safety and effectiveness (Olkowski, 1991; Speight and Evans, 2004). IPM concept is applied to all types of crop production and to damaging a variety of organisms such as weeds and nematodes, pathogens, and insects. It is argued that the implementation of IPM, as a crop protection solution, is often difficult and sometimes impossible in practice; because of pest dynamics, host-plant and climate interactions, the practicalities of crop production, and very often, the socioeconomic conditions prevalent in the region of interest (Speight and Evans, 2004).

IPM, organic agriculture and biological control have been suggested as appropriate approaches for pest management in Iran (Asgarinya, 2010; Molazadeh, 2010; Plant Protection Organization, 2010). According to the head of the Agricultural Research, Education and Extension Organization of Iran's Jihad –e-Agriculture Ministry, the strategy of this organization and ministry is to promote the organic agriculture instead of conventional agriculture through research and extension of reducing agricultural chemicals, particularly by establishing model farms. This ministry has also emphasized on monitoring, supervising and standardizing pesticides production and use (Agricultural Research Education and Extension Organization, 2010).

Iran accepted the Basel convention 1992 and became a party to the Rotterdam Convention in 2004. The Plant Protection Organization, as a part of the Ministry of Jihad-e- Agriculture, established in 1967, has been in charge of programming pesticide usage strategies and securing pesticide use based on international conventions. It has also been the authority responsible for supervising the import, production and distribution of pesticides; managing, supervising and legislating phytosanitary quarantine, and providing technical recommendations for both chemical and biological controls (Plant Protection Organization, 2005). According to the PPO, a transition has been stated from the chemically based pest management to the ecologically based pest management strategies. Its main pesticide usage strategies are: a) pesticides are used within the context of IPM, b) replacement of wide range pesticides with selective ones, c) extending of biological control method by mass rearing of beneficial insects and biopesticides production which is undertaken by the private sectors, and d) producing crops without chemical residue and providing food security.

Using pesticides have declined by 30 percent in the last five years (Agricultural Research Education and Extension Organization, 2010). According to the PPO's head, the production of fig, pomegranate, sugarcane and some citrus naturally need no pesticides and biological control. Moreover, the yellow and blue sticky traps/ cards are used in some rice and corn farms. He believes a significant progress has achieved in producing and consuming agricultural products, because the required knowledge, inputs and laws are available. Therefore, it is expected no any agricultural products will be produced with possibility of harming the environment and the public health by the next five years (Darabi, 2010).

A monitoring network of plant pests and diseases consisting of 4300 agricultural specialists (recently graduated agriculturists) has been established since 2006. They provide free visits to farms and deliver required information to farmers to prevent, monitor and control pests prior to their outbreaks. These experts have received training courses for their required competences. The PPO policy is to use these specialists for facilitating IPM extension in farms. Making non-chemical or less harmful inputs accessible to farmers is also another policy reported by the PPO.

Asgari (2009) has expressed that the national pest and disease research institution and provincial centres have carried out substantial studies for understanding plant pests and diseases, pesticides and plant cultivar resistant to pests for over 50 years. Over 270 pesticides have labelled by the MRL standard (a criteria to show pesticide residues and optimum pesticide use). Further efforts need to be done by research institutions and centres, for example understanding the economic damage level of pests, improving spray methods and sprayers, improving pesticide use, eliminating dangerous pesticides through replacing them by acceptable and less harmful ones, understanding and using new technology for pest control (Asgari, 2009).

The average amount of pesticides used in Iran is reported to be 0.7 kg/ha, which is less than that in the world (1 kg/ha). According to the PPO, pesticide use has decreased from 24 to 16.7 million litres in 2009. The agricultural arable and permanent lands in Iran are 17 million ha. This progress has been reported as the result of recruiting and training 4300 agricultural graduates in the pest monitoring network that provided advisory service to farmers to use pesticides appropriately. Moreover, other reasons of this decline can be related to removing subsidies which affected farmers not to use excessive amount of pesticides, developing the utilization of non-chemical and biological methods for field crops and greenhouse plants (vegetables and flowers), using pheromones and traps (funnel, yellow and blue sticky cards) for insect monitoring and control (Plant Protection Organization, 2010). The pesticide subsidies allocated to pesticides was almost 130 million dollars before 2009. These subsidies were considered for over 28 years in Iran. However, they were cut in 2009 due to a new policy for the economic adjustments and pesticides reduce in agriculture. Some efforts for pest management between 2005 and 2010 are discovering biological pest controllers from 7 to 25, implementing IPM from 200,000 ha to 900,000 ha, reducing pesticide use in palm orchards, reducing chemical controls against the sunn pests in cereal farms from 7.1 million ha to 900000 ha. During this period, 6 dangerous chemical pesticides were eliminated. In 2009, a 50-60 million dollar support was allocated to biological controls and IPM projects.

Studies in sustainable agriculture, and particularly in IPM projects, shows that these approaches need access to conservation sustainable technology, technical knowledge for learning, institutions and required supportive and conducive policies and regulations (Pretty, 1995, 1998). Thus, farmers' knowledge and participation are the key elements of achieving this approach. Some also link pesticide use patterns to the contexts within which they are used and discuss the role of regulation and legislation in reducing risk. Some studies demonstrate that the increased environmental awareness has gradually changed pesticides use (Devine and Furlong, 2007). These contexts and socio-economic factors, including knowledge may prevent the discard of pesticides.

Many have argued that Iranian farmers have low knowledge regarding how to use and how much to use pesticides. According to Agricultural Chemicals Distribution Manager of Agricultural Support Service in Iran, farmers' knowledge shortage of pesticide use spray time is the main problem of pesticide use in Iran. He has pointed out that the amount of pesticides and fungicides used in Iran is not more than the developed countries, but Iranian farmers have a shortage of information about the appropriate spray time and use (Molazadeh, 2010). Asgarinya (2010), the president of Plant Pathology Clinics Association in Tehran maintains that insufficient knowledge of farmers about modern technologies and methods is the main reason of traditional agriculture in Iran.

They have suggested increasing this knowledge. Some have argued that plant pathology clinics established during the last five year have been effective in improving agricultural products and suggest them as an appropriate approach for technical knowledge diffusion and extension regarding pest control in farms (Asgarinya, 2010).

There are experiences of using participatory approaches applying IPM worldwide, such as the participatory on-farm research or the farmer field school (FFS). Erbaugh, Donnermyeer, & Kibwika's (2001) evaluative study in Eastern Uganda showed that active participation of farmers can increase their IPM knowledge, if preliminary supports by the participatory research and extension approach is provided. However, this IPM project had covered a few beneficiaries, which were to some extent more socioeconomically advantaged.

2. METHODOLOGY

The purpose of this study was to assess farmers' knowledge and skills of IPM for the farm pest prevention and control. The research was to understand farmers' knowledge of using agrochemical and non-chemical pesticide in vegetable and apple production. It also investigated farmers' knowledge about the harmful consequences of pesticide use and their access to extension and research services. The study was conducted in the Zanjan Province of Iran using a case study through qualitative data collection techniques such as participatory observation, focus groups, transect walks, and structured and semi-structured interviews with 40 randomly selected farmers out of 150 farmers in the Nimavar Village. During transect walks and focus groups, an agricultural specialist from the private sector related to the Pest Monitoring Network of PPO was involved.

The qualitative data was collected through a participatory way with the researchers and farmers. For increasing validity and reliability, data was recorded, photographed, written and checked with them during data collection process. The questionnaire was also designed by the researchers and tested in a neighbouring village. Qualitative and quantitative analyses were applied to the data.

3. RESULTS

3.1. Community characteristics

The Nimavar Village is located in 21 km away from the Zanjan Ciry, one of the west-northern provinces with 330 km distance from Tehran. The village is located in a plain area with a cold and semi-arid climate. It has a good access to main road and transport with appropriate infrastructures such as electricity, safe water, telephone, gas, health centre, primary and secondary schools and other communication facilities. The nearest agricultural and extension service centers and private agro-chemical stores are in the Zanjan City, but an agricultural research station is located in 5 km from this village. According to the 2006 census, 1239 people (367 households) resided in this village, whose livelihood directly or indirectly related to agriculture. The main job of about 150-180 household heads was in agriculture, though over 250 members of these households worked in agriculture. The lands were distributed in several plots and were used mostly by an individual household.

The main crops were wheat, barley, alfalfa, and vegetables (carrots, cucumber, onion, and potatoes). The total agricultural lands in the village were 10000 ha land area (4000 ha irrigated and 6000 ha rainfed), but only 30 percent of the rainfed lands were cultivated each year (for wheat and barley production only). Almost 81 percent of irrigated lands were under vegetable cultivation. About 500 ha orchards, especially apple trees, were also in the village. According to the transect walks and focus groups, the orchard areas were much more than the current area, but because of pests attack they had dried and the area had decreased.

According to the interviews, in 2009, the average fellow and cultivated arable and permanent land areas of each household in the village were 12.6 ha (8.35 ha irrigated and 4.25 ha rainfed) and 1.1 ha correspondingly. Approximately 10 percent had not cultivated rainfed crops and 55 percent had less than 5 ha rainfed cultivation. In irrigated lands, 75 percent had less than 10 ha lands (35 percent less than 5 ha). In vegetable production, 70 percent of farmers produced in less than 5 ha areas. About 30 percent of the farmers had no orchards, 20 percent less than 1 ha and 40 percent 1-2 ha. Most of the farmers cultivated in their own lands, but about 10 percent of them had also used land tenure system through renting or lending their lands. Therefore, an individually small scale family peasant farming system mostly exists in this area and the average households' land areas are more than those in the country.

3.2. Participants' characteristics

The education level of the farmers interviewed was 30 percent illiterate, 40 percent at primary education, 25 percent the guiding education (1-3 years after primary education) and only 5 percent at secondary education. The average age and agricultural experience were 49 and 31 years respectively. 40 percent of them had 26-35 years and 30 percent over 35 years experience in agricultural activities. The minimum experience was 5 years. 90 percent of the participants in this research were male household heads and 10 percent were their first son.

3.3. Farmers' knowledge and experience of agrochemical use

Cultivation and existing agrochemical use. All farmers used fertilizers (mostly NPK fertilizers, which are locally called "white" and "black" fertilizers). Improved high quality seeds were used by 90 percent of farmers for carrot and cucumber production and by 60 percent of them for alfalfa and wheat production, but only 10 percent of them used these seeds for potato production. None of them reported improved seeds use for onion cultivation. Most farmers used chemical insecticides and herbicides for insect and weed control, but none of them reported utilizing biological or other non-chemical methods.

Herbicide use knowledge. According to the transect walks and focus groups, the most common herbicide used by the farmers was "Treflan herbicide", which was incorporated into the soil 2-3 days before plantation. According to agricultural specialists, this is a general herbicide, which can control a wide range of plants, particularly annual grasses. The characteristics of this herbicide show that it is labelled for many crops; major crops (such as spring wheat, alfalfa, sunflowers, dry edible beans and soybeans) and minor crops (including oilseeds such as safflower, canola and many vegetable crops). It is a pre-emergent herbicide, which provides long-lasting control of many annual grasses and broadleaved weeds by killing seedlings as they germinate, though it does not control established weeds.

This farmers' practice shows that they did not know the full characteristics of how to use the herbicide, because they cultivated their vegetable seeds only 2-3 days after this herbicide use. Therefore, many of their vegetable seeds were killed when they started to germinate in the soil. Thus, they need to allow more time between herbicide use and their cultivation.

Pesticide name knowledge. Farmers in focus groups also identified using Diazinon, Malathion (as Organophosphate pesticides which are absorbed via ingestion, inhalation and dermal contact), Fenvalerate (Sumicidin as a pyrethroid insecticide), Confidor (or IMIDACLOPRID as a systemic insecticide) and Volck oil. The farmers were then interviewed to report if they knew about these pesticides. Almost 70 percent of them reported the insecticides such as Malathion and Confidor and had used them in their carrot, cucumber and onion fields, but the least knowledge was related to the “Volck oil”.

Pest recognition. In focus groups and transect walks with farmers and the agricultural specialist, the most common apple trees' pest recognized by the agricultural specialist was named as a type of nut scale called “Eulecanium coryli or Eulecanium tiliae ” (*Shepeshak Nokhodi* in Persian), but local farmers called it a type of “mite”. The authors by collecting a sample of the pest from apple tree branches then identified it as a different name, Bituberculate scale or “Palaeolecanium bituberculatum” (*Shepeshak Dokohaneh*), which is a species of Coccidae soft scale. Approximately, 56 percent of the farmers in interviews identified this pest (but with the wrong name of mite).

Farmers had used the Volck Oil insecticide for controlling it. Agricultural specialists also suggested this insecticide for that pest. However, despite several use, farmers reported that it had no effect on the pest and most of their apple trees were dried or damaged. Farmers did not know its reason. Our interviews and focus groups showed that the farmers used this insecticide in the mid spring when the insecticides were hidden in their armored scale, so pesticides were less effective at this stage. Moreover, during transect walks, containers and bottles of different insecticide, herbicides and improved seeds were observed which had been expired before being purchased. Some of them also had not expiry or production date label.

Turnip moth or cutworm (Agrotis segetum) was another vegetable pest identified by the farmers. Many farmers did not know where this insect came from; i.e. they did not know the full cycle of this pest. Over 80 percent of the farmers distinguished this pest in their carrot fields. Almost 90 percent of farmers identified knowing about and using pesticides in their carrot fields. This may be because of the importance of carrot as the main vegetable product in the village.

Vegetable trips and white aphids were also reported by farmers and were observed in the vegetable fields during the transect walks, but not all the farmers could recognize these pests because they were very small or hidden between stem and roots.

Time and method of pesticide use: The pesticide use time was asked of the farmers and was compared with the appropriate suggested time by specialists. Only 26 percent of the farmers were aware of the appropriate time. Furthermore, only 32 percent of them knew the correct method of pesticide use. The focus groups and semi-structured interviews showed that most farmers utilized pesticides when they observed pests or the damage caused by pests. For the Agrotis caterpillar, they use pesticide in the early stages of vegetable grow which had a 2-3 months time until the crop harvest. Pesticides against the scale in the apple orchards were also applied using portable water flower or agricultural hand sprayers in May or June, while the harvest time was in September. Therefore, although there was sufficient time to remove pesticide residues, this type of sprayer may have not been suitable for trees.

Many farmers used the Fenvalerate pesticide against a different range of pests such as scales, aphids and cutworms. Some of them poured the pesticide in the water when they were irrigating their crops, by which they thought the cutworms can drink this poisonous water and die! Although Fenvalerate is a pyrethroid insecticide and can be applied against a wide range of pests, it may be ineffective for cutworms (Agrotis segetum) with this method. The problem of expired pesticide use still existed.

Pesticide use amount. The participants were asked to identify the amount of pesticides used, and then this amount was compared with the amount suggested by pesticide manufactures. This gave us a criterion to understand whether they utilize them excessively or they use them in terms of the information recommended. The interviews showed that most farmers had not excessive use (80-90 percent), so it was in accordance with the suggestions.

Understanding and applying withholding period. This criterion will show the period of time that must elapse between the last application of a pesticide and harvesting of plants; grazing or cutting for stock food; consumption by a human or animal after post-harvest use. To identify if the farmers have applied pesticide too close to harvest time, they were interviewed to report this period. For cutworms and trips control, this period was 2-3 months, but for aphids control in both vegetables and apple orchards, this period was short and different by various farmers. For apple production, the period was between 10-40 days, but for cucumber pests was between 2- 10 days (43 percent 2-4 days). This may cause chemical residues in vegetables or fruits at harvest time.

3.4. Knowledge about the importance of withholding period on human health

Most of them were aware of this impact. For cutworms chemical control, they thought there was enough time to remove residues, but 50 percent of them believed that the excessive amount of pesticides still cause chemical residues. For apple trees and cucumber pests, 85 percent of the participant knew this impact. 50-62 percent assessed it at a high impact, but 5-12.5 percent evaluated it as having no effect.

Most farmers’ view on the impact of pesticides on pest control was relatively positive (50 percent high and 30 percent to some extent). Moreover, their attitude towards the effect of excessive pesticide use on increasing pest resistance was various, but on average to some extent positive (50 percent somewhat, 25 percent low and 25 percent no effect). Their view on the negative effect of pesticides on human health was positive (70 percent yes with 93 high responses). This show despite this knowledge they still use pesticides, which may be because of lack of knowledge of or access to alternative methods. About 50 percent of them also identified the impact on ground water and non- pest insects (mostly to some extent). Therefore, some information gap is observed which need facilitating information to farmers.

3.5. Non-chemical pest management knowledge

Biological control. All farmers had no experience of knowledge about biological methods to control the pests mentioned above, though some methods exists and many scientists have observed that the conventional chemical controls are less effective and inefficient, for example for cutworms or the scales control. The only non-chemical method reported by some farmers (25 percent) was yellow and blue sticky cards / traps observed in TV or some neighbouring villages.

Preventing and monitoring pests. As explained, most farmers used improved seeds for some of their crops and had good knowledge about them. Only a few knew or heard about using pheromones, different traps and sticky cards to prevent or monitor pests. Mechanical operations were not much common to prevent both insects and weeds, except applying crop rotation system (by 75 percent of farmers). Only 20 percent of farmers disinfected their seeds (insecticide treatments of seeds and plantlets) prior to plantation. They also to some extent knew that ploughing may control weeds, but they were not aware of the impact of weed prevention and control on decreasing harmful insects. There were no signs of cultivating resistant varieties, removal of crop residues from fields, deep autumn ploughing, inter-row cultivations, optimal dates of early sowing, digging defensive ditches and furrows and watering in autumn or winter.

3.6. Extension and research programme access

Farmers had limited access to private or public extension programmes, particularly for pest management. The nearest agricultural and extension centre was located in 21 km. 60 percent of farmers had 1-2 visit during the last two years (mid 2007 to mid 2009) to this centre and had talked with extension agent. During the last two years, 40 percent of them had participated in 1-2 training courses and 50 percent had received mostly 1-2 electronic or printed materials regarding to agriculture. However, only few had observed demonstration farms. For pest management information, 25 percent of farmers had visited the agricultural and extension centre, but only 10 percent of them had received recommendations which were mostly about chemical pesticides. For this reason, only 15 percent had visited the agricultural research station, but only 5 percent of them had received information.

Moreover, only 15 percent had received private extension services through agricultural specialist cooperatives or the graduated. A private specialist regarding to plant pest and disease monitoring network had recently started her visit to the village and was to continue her job there for 2 months.

According to the focus groups, the farmers expressed their need to new information and continuous and easy access to extension agents. They identified that their main information source for pesticides was private input (seeds and agrochemicals) sellers, whose information were not much reliable. They also maintained that the printed materials received were not much easily readable by most farmers.

4. CONCLUSION

Farmers in this area had an individually small scale family peasant farming system. Their existing practice and knowledge regarding understanding pests’ life cycle, and appropriate time and method of pesticides use were to some extent low. The farmers hardly used non-chemical pest control methods (e.g. mechanical and biological techniques and natural enemies) and their awareness of using these methods was low. Although the farmers were to some extent aware of the side-effects of the excessive use of chemical fertilizers and pesticides, they still continued utilizing chemical inputs due to the shortage of knowledge of and little access to the alternative or sustainable techniques and facilities. The farmers showed little access to private or public extension or research institutions for this matter. It is suggested to improve agricultural extension service to facilitate participatory agricultural research, especially using the farmer field school approach and to provide the required chemical and non-chemical inputs in order to make information and inputs more available and accessible. This can make the implementation of IPM projects effective. A systemic way of understanding how to implement participatory IPM and FFS approach can give us a better insight for learning lessons about this approaches in the context of Iran’s agriculture.

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